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By A. R. Prater and A. G. L. Elliott

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STORAGE TESTS ON AIR-DRIED MUTTON MINCE

By A. R. Prater* and A. G. L. Elliott†

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Summary

A study has been made of the shelf life of air-dried mutton mince at a temperature of 77°F over a storage period of 2 years. The three different types of pack compared (in increasing order of shelf life) were: air pack, block pack in air, and nitrogen pack.

I. Introduction

Compression of dehydrated mince results in a saving in space and tin plate and, by exclusion of some of the air from the pack, in an increase of shelf life. However, during compression the texture suffers some damage with a resulting loss in quality.

In earlier work (unpublished data) the effects of a number of factors on texture during compression of dehydrated mutton mince were examined. From these results a procedure was devised for the production of good compact blocks with minimum damage to texture. In later work (Prater 1953) a procedure was devised for compression of dried slices. This procedure made possible the production of compact blocks using half the pressure normally used. It was applied to mutton mince and resulted in the production of blocks with improved texture (normally referred to as "fat blocks").

In making a general evaluation of the process it was necessary to compare the shelf life of fat blocks with air and nitrogen packs, with particular reference to particle size, effect of added fat, and presence of air in the pack.

II. Experimental

(*a*) *Design of Experiment*

The design consisted of six replicates of raw material with each replicate split into two levels of fat content. Nine treatments (three types of pack: air, fat block, and nitrogen, × three storages: initial, 12 lunar months, and 24 lunar months at 77°F) were applied at random to portions of each of the 12 lots of dried meat.

(*b*) *Equipment*

The greater part of the equipment used in these investigations has already been described in previous papers (Prater 1953; Howard, Prater, and Coote 1956).

The gas packing cabinet (Fig. 1) consisted of six separate compartments each designed to take one 401 × 202 can with a minimum of free space around the can. Each compartment was fitted with a hinged, quick-fastening door. The compartments were connected through stopcocks to a manifold, which could be connected

*Division of Food Preservation and Transport, C.S.I.R.O., Homebush, N.S.W.
†Division of Mathematical Statistics, C.S.I.R.O., Homebush, N.S.W.

to a vacuum pump (Edwards "Speedivac" high-vacuum pump) and manometer or to the gas supply plus manometer. A Campden manometer (Adam and Stanworth 1933) was used to measure the free space (headspace) and the pressure in the cans. The percentages of carbon dioxide and oxygen in the free space were measured by means of a Haldane gas analysis apparatus. Percentages of nitrogen were obtained by difference.

The gas packing and gas analysis equipment were housed in a constant-temperature room controlled at 77°F. Knowing the temperature of the gas, the pressure, the free space, the percentage of gas in the free space, and the weight of material in the pack it was possible to express the results as millilitres of gas (N.T.P.) per gram of meat.

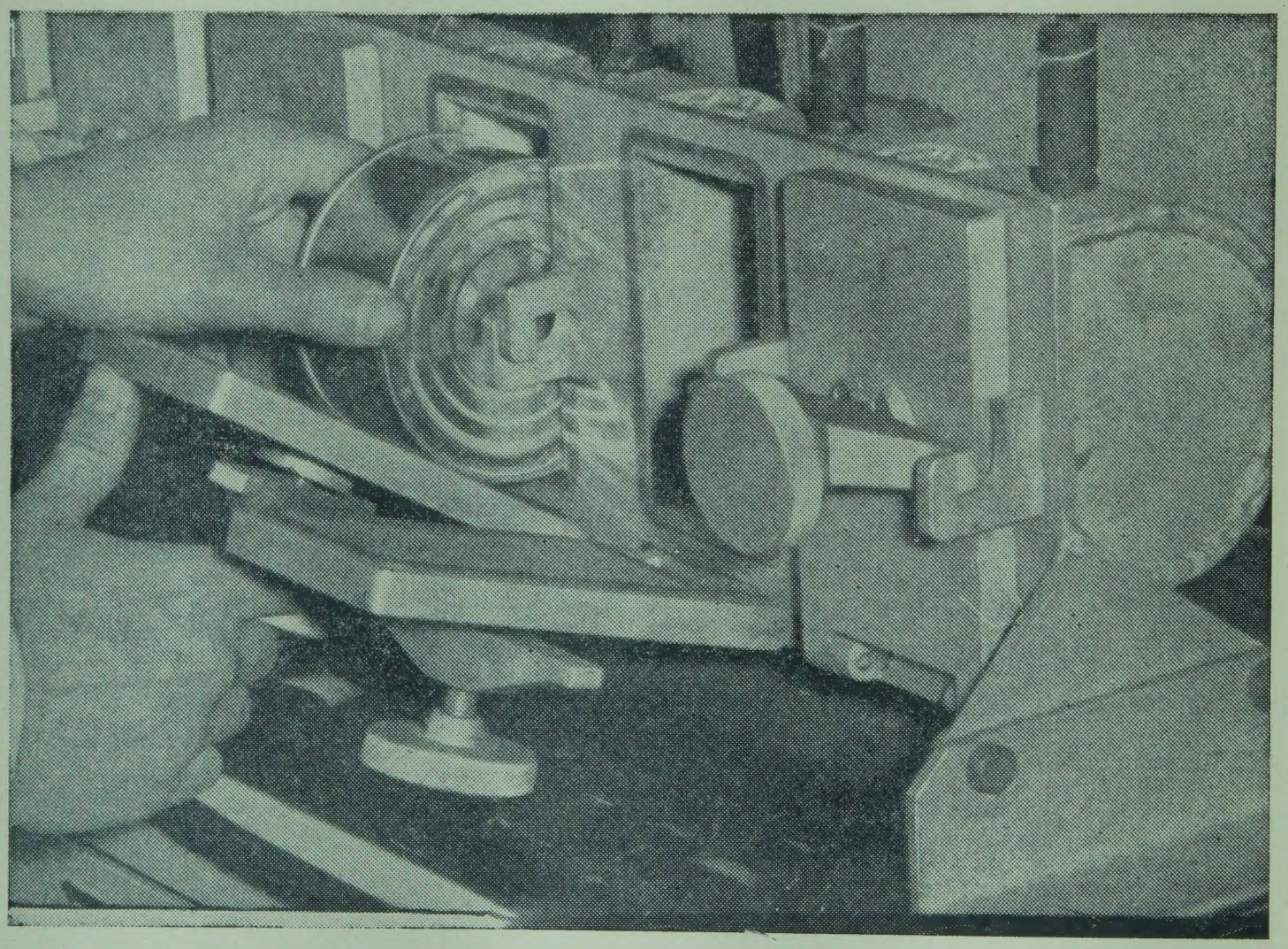

Fig. 1.—Gas packing cabinet showing five compartments.

(*c*) *Preparation of Material*

Four second-grade export carcasses were used for each of the six replications. One side of each was trimmed heavily before boning to give a quantity of meat of low fat content and the remaining side of each was trimmed lightly to give a batch of high fat content meat. After boning, the meat from each of the two groups was cut into cubes of approximately 3 in. ready for precooking.

Each group of meat was cooked for 45 min in steam at atmospheric pressure and then it was minced, while still hot, in a mincer with $\frac{1}{4}$-in. holes in the plate. The fat was separated from the cooking liquors, which were concentrated under vacuum to one-eighth of the volume (approx.) and added to the mince before drying.

It was necessary to dry either high or low fat content meat at the one time and, for this reason, the replicates were handled in pairs (i.e. one day's drying would consist of two groups of meat from two replications both with high fat or both with low fat).

The meat was dried in an up-draught air dryer at a temperature of 155°F falling each 15 min by 5°F until 135°F was reached. The remainder of the drying was carried out at this temperature. After drying, the meat was allowed to equilibrate; moisture and fat were determined; moisture was adjusted to 11 g per 100 g dry fat-free solids and then it was allowed to equilibrate before packing.

(*d*) *Packing*

The nine treatments (three types of pack × three storage periods) were applied at random to each of the 12 lots of meat (six replications × two fat levels).

(i) *Air Packs.*—Due to differences in density between high and low fat content samples, it was possible to pack 175 g meat into the 401 × 202 cans with the high fat content material but only 160 g with the low fat content material. The cans were sealed in a can closer and the seams were covered with Wood's metal as a precautionary measure against leakage.

(ii) *Nitrogen Packs.*—The quantities of meat were the same as for the air pack. The gas displacement technique used was as follows. The cabinet was evacuated for 20 min followed by flushing with oxygen-free nitrogen up to a pressure of 15 cm of mercury above atmospheric pressure, then evacuated for a further 10 min, and finally the nitrogen was let in again up to a pressure of 15 cm of mercury above atmospheric pressure. The positive pressure in the cans made it possible to remove the cans for soldering without intake of air.

(iii) *Fat Blocks.*—280 g meat was soaked for 15 min in mutton fat at a temperature of 158°F. The excess fat was drained off and the meat was pressed in dies (158°F) using a pressure of 252 lb/in^2 with a duration of pressure of 5 min. The block was dropped into the can, sealed, and cooled quickly in a blast of cold air. Seams were treated as with other packs.

(*e*) *Methods of Examination*

(i) *Moisture Content.*—Weighed duplicate samples (5–7 g) were dried for 16 hr in an air oven at a temperature of 212°F.

(ii) *Fat estimations.*—Fat estimations were made on initial air and fat block samples only, using the same samples as were used for the moisture determinations. Soxhlet extractions with light petroleum ether (b.p. 86–158°F) were continued for 4 hr, and, after removal of most of the solvent, the fats were dried in a vacuum oven for 1 hr at a temperature of 131°F and a pressure not in excess of 2 cm mercury.

(iii) *Densities.*—These were determined on the blocks in the press just before release of pressure. They were calculated from height readings, a fixed diameter, and the weights of the blocks after removal from the press.

(iv) *Gas Analyses.*—Carbon dioxide and oxygen percentages (nitrogen by difference) were determined on the nitrogen packs only at the initial examination,

but on all samples for the 12- and 24-month storage periods. Results were expressed as millilitres of gas (N.T.P.) per gram of meat.

(v) *Organoleptic Tests.*—On each of 18 days there were two sittings (high fat content and low fat content meat) each consisting of three packs: air, fat block, and nitrogen pack.

Fifty grams of each sample was placed in a crystallizing dish and covered with 167 ml of hot saline solution (0·5 per cent.). The dishes were covered with watch-

TABLE 1

PALATABILITY SCORING SCALES

Characteristic	Points
Flavour	
Meat flavour	8–0
Persistency of meat flavour	
Off flavours:	
Staleness	0–8
Pressure-cooked	
Burnt	
Foreign	
Texture	
Particle size	8–0
Fatness	
Juiciness	
Tenderness	
Woolliness	0–8
General	
Colour	8–0
Grade	4–0

glasses and placed in an atmospheric steamer for 1 hr. After draining, the samples were served warm to the tasters, three being present at all sittings. The score sheet used by the tasters was as shown in Table 1.

III. RESULTS

(*a*) *Moisture and Fat Determinations*

Analyses of variance on the fat determinations showed significant effects both for level of fat and type of pack (loose or block) with a significant interaction between the two. This is owing probably to the low fat content meat in the block packs retaining fat added prior to compression (Table 2). The low fat content meat in the air pack had a significantly lower fat content than the other three treatments.

There was a significant difference in the moisture contents between the samples stored for 12 and 24 months but the means bear no relationship to time.

The type of pack and the level of fat content produced significant, interacting effects which were due to the low fat content meat of the block packs having a higher fat content than it had when the moisture content was adjusted.

(*b*) *Densities in the Press*

Analyses of variance on the density results measured before release of pressure showed the blocks of high fat content meat had significantly higher densities than

TABLE 2

MEAN VALUES FOR FAT AND MOISTURE DETERMINATIONS

Determinations	Storage Time	Type of Pack	High Fat Content (%)	Low Fat Content (%)	Mean (%)	n′*	Level of Sig. (%)	Least Sig. Diff. at *P* of Previous Column (D.F. in brackets)†
Fat content	Initial	Air	38·32	28·82	—	12	1	Cols. 4·18 (5)
		Block	37·56	36·62	—		1	Rows 3·40 (10‡)
Moisture content	Initial		—	—	6·51	72	1	0·14 (80)
	12 months	Mean	—	—	6·60		5	0·10 (80)
	24 months		—	—	6·41			
Moisture content	Mean	Air	6·40	7·09		36	1	Rows 0·34(10‡)
		Block	6·28	6·14				
		Nitrogen	6·23	6·88			0·1	Cols. 0·25 (80)

*Number of determinations used in mean.

†Cols.: for testing differences between individual entries in the same column. Rows: for testing differences between individual entries in the same row.

‡Approximate value.

those of the low fat content meat. Mean density figures (n′ = 18) for high and low fat content blocks were 1·172 and 1·132 respectively. The least significant difference at the 1 per cent probability level with five degrees of freedom was 0·027.

(*c*) *Gas Concentrations*

The means for the gas concentrations have been recorded in Table 3. Oxygen concentrations were practically all zeros and were not examined statistically.

The statistical results for nitrogen and carbon dioxide have been set out in Table 4.

The amount of nitrogen in the packs is in the decreasing order of nitrogen pack, air pack, block pack; an order which would be expected. The packs of low fat content meat in air and nitrogen have a greater amount of nitrogen than the high fat content meat packs. The reverse order is found in the block packs. The low fat content air and nitrogen packs contained less meat than the corresponding high fat content packs (160 g *v.* 175 g). The low fat content meat in the block packs gained weight during compression due to retention of added fat.

The air packs contained more carbon dioxide than the nitrogen or block packs. The air packs with low fat content meat contained more carbon dioxide than those with high fat content meat and the block packs were significantly in the reverse order.

(*d*) *Taste Tests*

Analyses of variance on taste test scores were carried out whenever the data allowed. Criteria for deciding were: a reasonable range of scores, homogeneity of

TABLE 3

EFFECT OF TREATMENTS ON HEADSPACE GAS COMPOSITION

Values shown are the mean of six cans. Volumes are expressed at N.T.P.

Type of Pack	Storage Time (months)	Carbon Dioxide (ml/g meat)		Oxygen (ml/g meat)		Nitrogen (ml/g meat)	
		High Fat	Low Fat	High Fat	Low Fat	High Fat	Low Fat
Air	0	—	—	—	—	—	—
	12	0·023	0·032	0·000	0·001	0·957	1·212
	24	0·028	0·034	0·000	0·000	0·961	1·208
Block	0	—	—	—	—	—	—
	12	0·006	0·003	0·000	0·000	0·309	0·213
	24	0·006	0·003	0·000	0·000	0·310	0·209
Nitrogen	0	0·001	0·001	0·001	0·001	1·119	1·359
	12	0·004	0·007	0·000	0·000	1·129	1·400
	24	0·006	0·006	0·000	0·000	1·128	1·408

taster variances, and normality of distribution of residual errors. Where it was considered an analysis of variance was not appropriate, a χ^2 analysis was carried out after classifying the scores as greater than or less than some selected value; this selected value was in general chosen so as to emphasize differences between treatments noted during examination of the data.

(i) *Tenderness* (*Table* 5).—There was a tendency for the meat to become less tender with increasing time of storage but there was disagreement between tasters. There was also a tendency for the high fat content material to be less tender than the low fat content material. The block packs were significantly less tender (1 per cent. probability level) than the air and nitrogen packs.

(ii) *Woolliness* (*Table* 5).—There was a significant increase in woolliness with time of storage. Scores for the initial samples were significantly less than those for 12 months which were less than those for 24 months.

(iii) *Juiciness* (*Table* 5).—Juiciness decreased significantly with increased storage time but tasters disagreed on the extent of the change. The initial scores and the 12 and 24 months scores differed significantly.

(iv) *Particle Size* (*Table* 5).—Tasters found the block packs had granules of significantly smaller size than those of the air and nitrogen packs.

(v) *Meat Flavour* (*Table* 5).—There was a tendency for the scores to decrease slightly with increasing time of storage. However tasters disagreed and the effect was of doubtful significance.

TABLE 4

SUMMARY OF TREATMENT MEANS CORRESPONDING TO SIGNIFICANT TREATMENT EFFECTS ON HEADSPACE GAS COMPOSITION

Volumes are expressed at N.T.P.

Gas	Type of Pack	High Fat Content (ml/g)	Low Fat Content (ml/g)	Mean (ml/g)	n'*	Level of Sig. (%)	Least Sig. Diff. at P of Previous Column (D.F. in brackets)
Nitrogen	Air Nitrogen			1·084 1·266	24	0·1	0·041 (30)
	Mean air & nitrogen	1·043	1·307	—	24	0·1	0·055 (5)
	Block	0·309	0·211	—	12	5 1	0·064 (5) 0·101 (5)
Carbon dioxide	Air	0·024	0·033	—	12	1	0·007 (5)
	Block Nitrogen	0·0056 0·0052	0·0032 0·0052	— —	12	1 5	Rows0·0019 (34†) Cols. 0·0010 (29)

*Number of determinations used in mean.

†Approximate value.

(vi) *Stale Flavour* (*Table* 5).—Stale flavour increased significantly with increasing time of storage. Initial scores were not included in the analysis of variance because of the presence of a large number of zero scores and were not analysed. Air packs scored significantly higher than block packs, which in turn scored higher than nitrogen packs.

(vii) *Foreign Flavour*.—The scores for 12 months and 24 months were mainly zeros and were not analysed, but in the initial scores two tasters scored the block packs significantly higher than the air or nitrogen packs (χ^2 analysis after classifying scores as zeros and non-zeros).

(viii) *Fatness*.—Similar results were obtained for fatness as were obtained for foreign flavour. The fat blocks were more fatty than the air and nitrogen packs in the initial samples only.

(ix) *Pressure-cooked Flavour*.—A χ^2 analysis was carried out on the scores after 24 months' storage by dividing them into zeros and non-zeros. The low fat content samples showed a significantly greater number of non-zero scores.

(x) *Grade Scores* (*Table* 6).—The scores for the two storage periods were submitted to an analysis of variance. The initial scores were analysed with a χ^2 analysis after classifying the scores into "fours" or "less than fours". The overall totals suggested a decrease in grade with increasing time of storage, most marked in the air packs, and a lowering of grade in the order nitrogen pack, block pack, and air pack. However, interactions were present, both with treatments (pack and storage)

TABLE 5

PALATABILITY MEAN SCORES

Characteristic	Pack	Storage			n′*	Level of Sig. (%)	Least Sig. Diff. at P of Previous Column (D.F. in brackets)
		Initial	12 months	24 months			
Tenderness	Averaged over packs	5·86	5·18	5·09	108	—	—
Woolliness	Averaged over packs	2·56	3·71	4·10	108	5 0·1	0·37 (20) 0·68 (20)
Juiciness	Averaged over packs	5·21	3·70	3·77	108	0·1	0·87 (20)
Meat flavour	Averaged over packs	4·20	3·80	3·88	108	1	0·29 (20)
						(12 and 24 months only)	
Stale flavour	Air	0·22	4·17	4·86	36		
	Nitrogen	0·25	1·94	2·06	36	5	Cols. 0·34 (20)
	Block	0·25	2·64	2·78	36	0·1	Rows 0·70 (16†)
Particle size	Air		5·44		108	5	0·15 (30)
	Nitrogen		5·34		108	0·1	0·27 (30)
	Block		4·70		108		

*Number of determinations used in mean.

†Approximate value.

and with treatment and taster. At the initial examination, the block packs were significantly lower in grade than the air packs and the nitrogen packs, although the difference was not great; at 12 months both the nitrogen and the block packs scored significantly higher than the air packs, while at 24 months the nitrogen packs were significantly higher than the block packs, which in turn were significantly higher than the air packs.

IV. Discussion

The difference in nitrogen concentration between the air and nitrogen packs is smaller than might be expected because the meat temperature in the air packs on

closure was close to 32°F. In later experiments the pressure was adjusted to atmospheric at a temperature of 77°F.

Foreign flavour and excessive fatness were detected in a number of block packs initially, but not at the later tastings. The first was due to a very slight off-flavour in the added fat (graded as first-grade edible mutton tallow) and the second to the presence of a greater amount of fat in the rendered form.

TABLE 6

MEAN GRADE SCORES

Twelve determinations used in means

Tasters	Initial			12 Months			24 Months			Level of Sig. (%)	Least Sig. Diff. at P of Previous Column (D.F. in brackets)*
	Air	Block	Nitrogen	Air	Block	Nitrogen	Air	Block	Nitrogen		
P	4·00	4·00	4·00	1·75	3·17	3·25	0·75	2·00	2·67	0·1	Packs 0·89 (59†)
T	4·00	3·75	4·00	0·50	1·50	2·33	0·25	2·17	2·58		
E	3·83	3·00	3·67	0·83	1·50	2·92	0·25	0·83	2·42	1	Storage 0·73 (42†)
Mean	3·94	3·58	3·89	1·03	2·06	2·83	0·42	1·67	2·56		

*Packs: for testing differences between packs for a particular taster and storage. Storage: for testing differences between storages for a particular taster and pack.

†Approximate value.

It should be noted that the grade scores, as allotted by a small analytical panel, are not true acceptability scores, but it is believed that they provide a reasonable and conservative estimate of shelf life. If a score of 2 on the grade scale is accepted as the lower limit of acceptability for culinary use, then the nitrogen packs should have a shelf life of 2 years and block packs 14–18 months at a storage temperature of 77°F.

It has been demonstrated that it is possible to produce compressed packs, which compare favourably with nitrogen packs, both in storage life and in acceptable texture. A further increase in shelf life might be expected by exclusion of the residual oxygen in the block packs (i.e. gas packing).

Block packs, produced by ordinary blocking methods, can be recognized by taste after reconstitution owing to the presence of a flavour, believed to be due to a texture effect, resulting from compression. Blocks produced by the method discussed in this paper were practically free from this "flavour-texture" effect.

V. ACKNOWLEDGMENTS

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